

NOVEMBER 2021

**SPECIAL**

DEVELOPING A  
TRUSTED DIGITAL  
INNOVATION HUB

**FEATURE**

TO QUANTUM AND  
BEYOND

**COMMENTARY**

DEFINING DEEP TECH'S  
NEXT CHAPTER

**FEATURE**

PREDICTING THE NEXT  
VIRAL FOOD TRENDS

# RIE NEWS

SG GUIDE TO TECHNOLOGY, INNOVATION & ENTERPRISE



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# RESEARCH ROUNDUP

## ANTIBODIES THROUGH HAMSTER CELLS



Antibody drugs are commonly mass-produced in Chinese hamster ovary (CHO) cells because they grow rapidly under lab conditions. However, the media used to culture them is expensive, driving up the cost of production for drug manufacturers. To improve the efficiency of antibody production in CHO cells, a team from the Agency for Science, Technology and Research (A\*STAR) worked with researchers from Merck & Co. to identify specific CHO cell genes that would improve antibody production when silenced. Using a large-scale small interfering RNA (siRNA) screen and CRISPR-Cas9 technology, the researchers have pinpointed genes that can enhance antibody production in Chinese hamster ovary cells.

Decontaminating everything may be doing more harm than good as the overuse of antibiotics and disinfecting agents is linked to the rise of antimicrobial resistance. To combat this emergent threat, researchers from A\*STAR have begun looking to self-sanitising surfaces in nature for inspiration. They identified that the nanoscopic needle-like patterns on the surface of cicada and dragonfly wings destroy microbes physically instead of chemically, 'popping' microbes that land on them. The scientists were able to mimic these natural biocidal nanostructures and devised ways of lowering existing barriers around manufacturing self-sanitising nanostructure surfaces. They developed needle-like iron oxide 'nano-urchins' that can puncture microbial cell walls and membranes, which can be mixed into paint, paving the way for a new class of self-sanitizing surfaces.

## SELF-CLEANING SURFACES



Image: A\*STAR

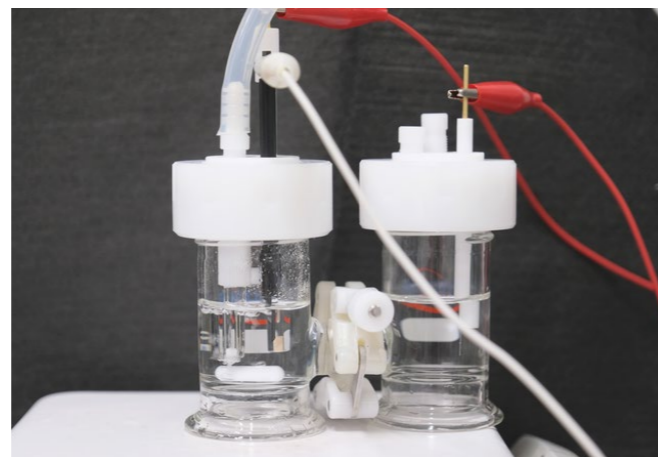
## HYUNDAI AND NTU TO RUN AI RESEARCH



Nanyang Technological University (NTU) and South Korean car manufacturer Hyundai Motor Group have inked an agreement to run four research projects focusing on the production of electric vehicles and future mobility technologies. The four pilots will look at the use of artificial intelligence (AI) and additive manufacturing technologies. The research initiatives aimed to develop applications that could pave the way for next-generation car manufacturing facilities. One of the projects, for instance, would look to build machine learning algorithms for vehicle image processing, which could be tapped to check the quality of battery electric vehicles. The two partners also planned to run 3D printing competitions in automotive engineering, which they hoped would spur interest in electric vehicle manufacturing and nurture new talent in the sector. NTU students and researchers also would be able to tap Hyundai's industry experts to exchange ideas.

A team of international scientists led by NTU has devised a new 'greener' method to make a key compound in fertiliser, and that may pave the way to a more sustainable agricultural practice as global food demand rises. The new method produces a compound known as 'urea', which is a natural product found in the urine of mammals, and an essential compound for fertilisers that is mass-produced industrially to increase crop yields. The joint research team found a way to greatly improve an existing alternative approach to urea production known as electrocatalysis – using electricity to drive chemical reactions in a solution. This new method to produce urea may inspire the future design of sustainable chemistry approaches and contribute to 'greener' agricultural practices to feed the world's growing population.

## SUSTAINABLE GREEN FERTILISER



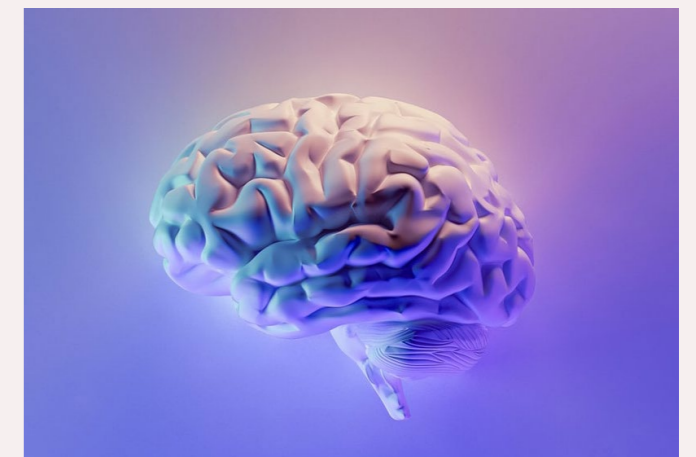
## HOLOMEDICINE RESEARCH

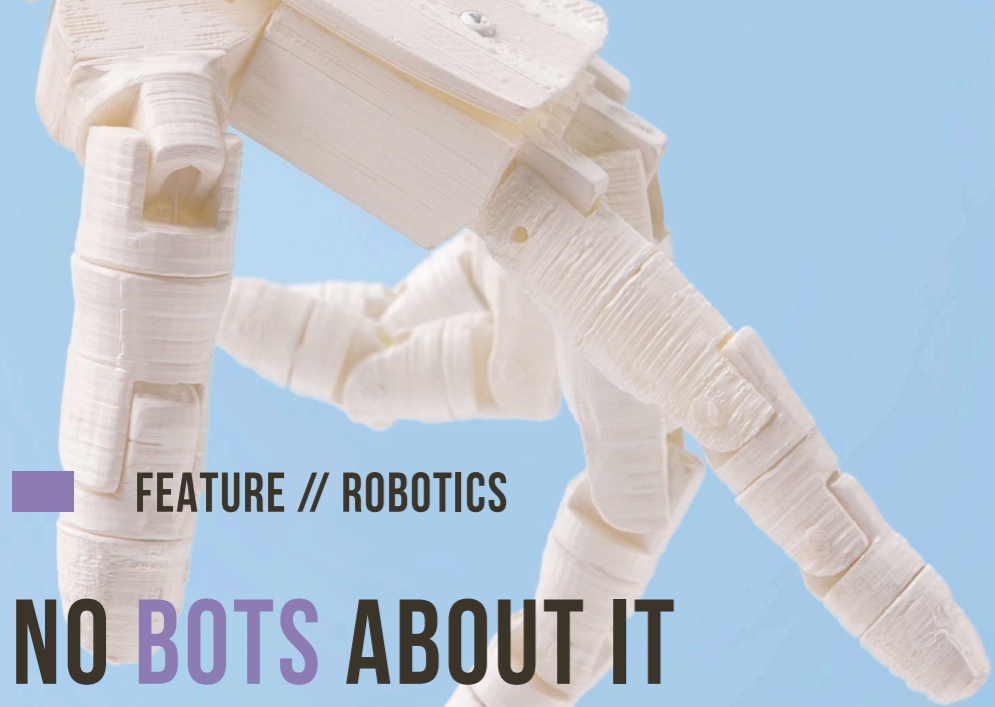


The National University Health System (NUHS) has embarked on a R&D programme to explore the use of mixed reality (MR) technology in clinical care. This would augment clinical processes, and enhance both undergraduate and postgraduate education. While the use of holographic technology in operating theatres is still nascent, NUHS hopes to apply it in multiple fields of surgery. A team of neurosurgeons at NUH has initiated a study to assess the feasibility of using holographic technology to spatially locate brain tumours when operating on patients. The research programme hopes to support the development of next-generation clinical applications and improve patient safety.

Many electronic devices today are dependent on semiconductor logic circuits based on switches hard-wired to perform predefined logic functions. Physicists from the National University of Singapore (NUS), together with an international team of researchers, have developed a novel molecular 'memristor', or an electronic memory device, that has exceptional memory reconfigurability. Unlike hard-wired standard circuits, the molecular device can be reconfigured using voltage to embed different computational tasks. The energy-efficient new technology can potentially be used in edge computing, as well as handheld devices and applications with limited power resource. The researchers said that the technology might first be used in handheld devices, like cell phones and sensors, and other applications where power is limited.

## BRAIN-INSPIRED MEMORY DEVICE



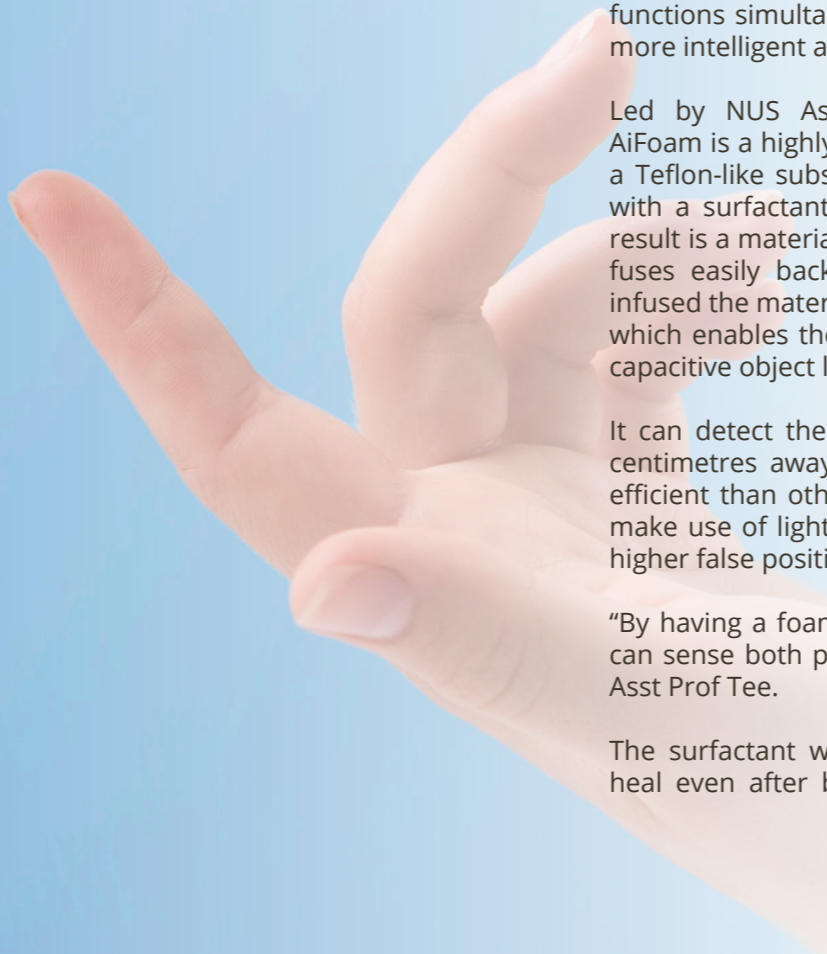


## FEATURE // ROBOTICS

# NO BOTS ABOUT IT

Artificial intelligence (AI) and robotics are a powerful combination for automating tasks and have introduced flexibility and enhanced learning capabilities for various applications.

We look at four robotic innovations in Singapore that is paving the way towards a new age of robotics that could be a new Renaissance.



### Robots with a Human Touch

Robots and machines are getting smarter with the advancement of artificial intelligence, but they still lack the ability to touch and feel their subtle and complex surroundings like human beings. Now, researchers from the National University of Singapore (NUS) have invented a smart foam that can give machines more than a human touch.

Called artificially innervated foam, or AiFoam, the soft and sponge-like material mimics the human sense of touch, can sense nearby objects without touching, and repairs itself when damaged. It is also the first smart foam in the world that performs these functions simultaneously, potentially making robots more intelligent and interactive.

Led by NUS Assistant Professor Benjamin Tee, AiFoam is a highly elastic polymer created by mixing a Teflon-like substance, known as a fluoropolymer, with a surfactant that lowers surface tension. The result is a material that, when separated into pieces, fuses easily back into one piece. The team then infused the material with microscopic metal particles which enables the foam to sense the presence of a capacitive object like a human finger.

It can detect the presence of human fingers from centimetres away. Moreover, its detection is more efficient than other proximity sensors that typically make use of light and reflections which can lead to higher false positive or negative rates.

“By having a foam with our special formulation, we can sense both pressure and proximity easily,” said Asst Prof Tee.

The surfactant within the foam enables it to self-heal even after being cut, making it ideal for use

in applications like prosthetics. The foam can be stretched to more than twice its length – by 230 per cent – without breaking. To heal cuts, the researchers heated it to 70 degrees Celsius over four days. The material healed about 70 per cent, and could still be stretched to almost twice its length (180 per cent).

The NUS team is exploring partnerships with robotics companies, as well as looking to expand the use of AiFoam to areas like robotics and prosthetics, to enable more seamless interactions between humans and machines.

### Sight through WiFi

Integrated camera systems help robots ‘see,’ but they fall short in certain contexts, like when sensors do not have a clear line of sight or when backgrounds are blank and featureless.

Making use of WiFi signals that are commonplace in indoor areas, a team led by Le Zhang from the Agency for Science, Technology and Research (A\*STAR) designed a unique non-visual system that helps robots orient themselves in new environments.



The system involves using a mobile device to survey a location where WiFi access points have been installed. It saves the unique WiFi received signal strength (RSS) from each access point and records them in a map

database. Whenever a robot or another device sends RSS details within the surveyed space, information from the database could be used to estimate its exact location.

This laid the foundation for the A\*STAR team to develop a technique to accurately turn RSS information into location coordinates.

Their model, called Deepfuzzy, uses fingerprinting-based algorithms; named after the fact that virtual ‘fingerprints’ are taken in an area that serves as a priori knowledge for robot localization or navigation.

Zhang said DeepFuzzy can be used in tasks ranging from visual surveillance to image super-resolution. He and his team plan to take what they learned from this project to produce better deep learning techniques with useful applications.

**Tiny but Mighty**

While robots are generally known to be big, bulky, and perhaps clumsy at times, a team of scientists at Nanyang Technological University (NTU) has created tiny millimetre-sized robots. Measuring about the size of a grain of rice, these robots could pave the way to possible future applications in biomedicine and manufacturing.

The researchers created the miniature robots by embedding magnetic microparticles into biocompatible polymers — non-toxic materials that are harmless to humans. The robots are ‘programmed’ to execute their desired functionalities when magnetic fields are applied.

The robots are controlled remotely by an operator using a computer programme that precisely varies the strength and direction of magnetic fields

generated by an electromagnetic coil system. The operators may also control the tiny robots to reach confined and enclosed spaces currently inaccessible to existing robots, making them particularly useful in the field of medicine.



Led by Assistant Professor Lum Guo Zhan, the NTU team said that the miniature robots may also inspire novel surgical procedures for ‘difficult-to-reach’ vital organs such as the brain in future. However, they added that further testing still needs to be done before being deployed into targeted medical applications.

Co-authors of the research, NTU PhD students Xu Changyu and Yang Zilin said, “Besides surgery, our robots may also be of value in biomedical applications such as assembling lab-on-chip devices that can be used for clinical diagnostics by integrating several laboratory processes on a single chip.”

The NTU team is now looking to make their robots even smaller, on the scale of a few hundred micrometres, and to ultimately make the robots fully autonomous in terms of control.

**Polymer Hybrid Materials for ‘Soft’ Robots**

With robotics becoming more nimble, better vision and human-like senses, researchers from the Singapore University of Technology and Design

(SUTD) have developed the largest range of silicone and epoxy hybrid resins for the 3D printing of wearable devices, biomedical equipment, and soft robotics.

Although robots have been portrayed as hard and metallic structures, a new class of pliable machines called soft robots is gaining attraction quickly. This new class of robots were inspired by the flexible forms of living organisms, which creates new opportunities for robotic technologies such as fluid movement, sensing, object grasping and manipulation, among other things.

However, such robots are mainly fabricated through traditional casting methods, which limits the geometries and complexity that could be achieved.

The novel range of polymer hybrids developed by the SUTD researchers exhibited a wide range of mechanical characteristics – from very soft to very stiff for use in soft robotics and easier assembly in traditional hard mechatronics components.

The polymer hybrids also displayed excellent toughness and chemical compatibility to withstand large strains. It can also be processed through ‘direct-ink writing’, which is an extrusion-based 3D printing method. This enables advanced digital manufacturing of complex structures easily.

Principal investigator Assistant Professor Pablo Valdivia y Alvarado, said, “Most fabrication approaches are predominantly manual due to a lack of standard tools. But 3D printing or additive manufacturing is slowly coming into play as it facilitates repeatability and allows more complex designs — improving quality and performance.”

More importantly, the SUTD team highlighted

how the polymer hybrid could overcome issues on the potential of soft robotics being limited in its robustness and applicability. The newly developed resins are tougher and will also allow for more robust integration of mechatronic components in 3D printed multi-material structures.



For instance, the integration of mechatronic components such as printed circuit boards (PCB), sensors, batteries, pneumatic fittings, cables, and pumps, into soft and composite bodies continue to be a challenge, while design complexity and fabrication control are hindered by the traditional moulding and casting approaches used for integration.

The materials were also observed to have excellent interfacial toughness, higher precision in complex structures and better fabrication control for the integration of mechatronic components.

“Our advanced fabrication approaches facilitate robust material combinations at multiple scales and high resolutions enabling novel applications to a broad range of key sectors, such as wearables, healthcare, and more specifically soft robotics,” said Asst Prof Alvarado.



SPECIAL

# DEVELOPING A TRUSTED DIGITAL INNOVATION HUB

In RIE2025, the **Smart Nation and Digital Economy (SNDE)** domain will continue to support the development of strategic and emerging technologies and enhance the translation of digital capabilities to industry.

The aim is to achieve Singapore's Smart Nation ambitions, and leverage growth opportunities in the digital economy. The SNDE domain will also focus on five tech areas: i) Artificial Intelligence, ii) Cybersecurity, iii) Trust Technologies, iv) Quantum and v) Communications and Connectivity.

In this special segment, we will explore some of the projects under the SNDE domain that will transform Singapore into a **trusted digital innovation hub**.



## SPECIAL // ARTIFICIAL INTELLIGENCE

# BRINGING ARTIFICIAL INTELLIGENCE UNDER ONE ROOF

A new AI mega-centre at SUTD will bring together resources, equipment and the collective minds of researchers and students to further the development of AI in Singapore. Deputy director of the upcoming centre, **Associate Professor Georgios Piliouras**, shares more.



(L-R) SUTD AI Programme sector lead Prof Tony Quek; Deputy Director of SUTD AI mega-centre, Assoc Prof Georgios Piliouras; Asst Prof Malika Meghjani.

To support the growth of local artificial intelligence (AI) capabilities and to bring together different fields of AI projects under one roof, the Singapore University of Technology and Design (SUTD) is setting up an AI mega-centre to serve as a hub for research, teaching and collaboration.

SUTD Associate Professor Georgios Piliouras, who is the deputy director of the upcoming AI mega-centre, said that Singapore's AI infrastructure is currently largely decentralised, with researchers having to be in charge of their own computational assets such as procurement, maintenance and administration in their "individual research islands". Hence, the new centre will be able to help organise these infrastructures more efficiently.

"By collecting these infrastructures under a single mega-center, we can optimise the availability of resources and equipment to both researchers as well as students. We can also take advantage of economies of scale to reduce operational costs, allowing researchers to work with a more effective and lean operational system to collectively achieve AI research goals," he added.

The mega-centre will also house high powered computing infrastructure and set up research labs that facilitate data collection, dataset development

and management of big data, all of which are available to the SUTD community.

Assoc Prof Georgios shared that one key goal of the AI mega-centre is to remove boundaries - boundaries not just between machines but between people. SUTD envisions that the centre will enhance communication across different sub-areas of AI and potentially allow for the emergence of exciting cross-disciplinary research.

The mega-centre will be home to a wide range of different AI research, broadly organised in four focus areas:

- **Theory and fundamentals of AI:** How to design systems with provable guarantees;
- **Discovery by AI:** How researchers can use AI to extract useful knowledge and wisdom from the multiplicity of data in the world;
- **Human-AI interaction:** How humans can communicate with these new AI systems; and
- **Infrastructure for AI of the future:** How researchers can explore new AI Systems

"We will be actively pursuing research in numerous AI domains, including robotics, computer vision, natural language processing and many more. This includes a whole spectrum of projects that are at different stages of development, from fundamental theory to those that are close to commercialisation," said Assoc Prof Georgios.

### AI Projects by 30 Professors

For the initial phase, the AI mega-centre is working on projects by around 30 SUTD professors, and one of them is SUTD Assistant Professor Malika Meghjani, whose AI projects involve research topics in multi-agent coordination, robot vision and learning.

Her projects focus on field robotics, namely robots on land, in air, underwater and on the water surface. She has extensive experience working with self-driving cars in urban environments, marine robots for search and rescue missions and underwater robots for coral reef monitoring.

Asst Prof Meghjani explained that all these robots require different levels of coordination through AI.

She said, “In a disaster scenario, the search-and-rescue robot will need to rescue each survivor in the shortest time possible, while making sure to find all of the survivors. This means we need to develop

algorithms that give theoretical bounds and can also be applied in real-time to capture the targets efficiently.”

She also added that, “This algorithm can also be extended into the application of clearing marine trash where the time constraints are not stringent while aiming for capturing all the trash.

“The problem domain and the respective constraints may differ, but by implementing state-of-the-art AI techniques, we can infer patterns and behaviours to make forward predictions for intelligent and interactive robotic applications.”



Artist's impression of the upcoming SUTD AI mega-centre.



One of the AI projects that SUTD Asst Prof Malika Meghjani is working on involves research on autonomous surface vehicles for multi-target search. Targets can be survivors from a disaster scenario or passively floating marine trash.

Platform for Collaboration

Asst Prof Meghjani explained that the mega-centre could provide a platform for multiple internal collaborations at SUTD, as well as strengthen research capabilities to reach out for external grants and partnerships.

“For us who are more interested in software development, we can then partner with another group of researchers in the centre, whose expertise might be in robotics hardware innovation, to work on real-world deployment together.”

“This lab space will be very attractive for students to work in collaboration, just like an academic home.”

Given how telecommunication technologies like 5G and 6G closely tie in with AI, the centre will also support SUTD to lead the Future Communications Research and Development Programme, which is also helmed by the centre’s director, SUTD AI Programme

sector lead Professor Tony Quek.

This will enable AI projects under the centre to tap on telecommunication technologies from the get-go, with features like a control hub for 5G-powered drones and a testbed for beyond-5G technologies.

With Singapore’s good progress in AI research, Prof Georgios hopes that the mega-center can continue to be active in guiding the local AI ecosystem, to build a collaborative network between research to collectively make use of AI to improve people’s lives.

“By collecting these infrastructures under a single mega-center, we can optimise the availability of resources and equipment to both researchers as well as students.

Assoc Prof Georgios Piliouras  
Deputy Director of SUTD’s upcoming AI mega-centre

## SPECIAL // ARTIFICIAL INTELLIGENCE

# SPEEDING UP CARDIOVASCULAR DIAGNOSTICS

A joint team of scientists from Singapore has developed a new tool that could lead to faster diagnosis of heart diseases. One of the project's co-leaders **Prof Ng Yin Kwee** from the Nanyang Technological University, shares more about the unique innovation that looks set to make waves in the medical diagnostics industry.

Electrocardiogram or ECG is a staple in medical diagnostics when it comes to cardiovascular diseases.

It is also one of the simplest and fastest tests used to evaluate the heart. It involves attaching 12 sensors or 'leads' onto various parts of the body, and the process takes roughly five minutes to generate a reading.

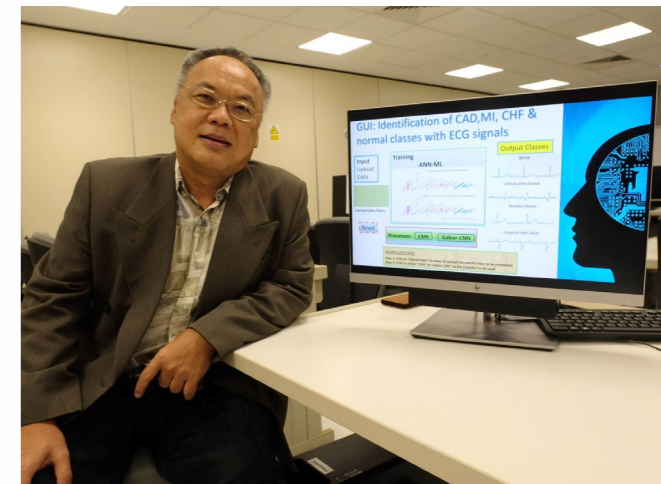
However, ECG tests comes with challenges such as uncertainties in the frequency of imaging tests in different situations. ECGs also require a specialist to assess the results and mull through the long readings to identify anomalies and tell-tale signs of cardiovascular diseases.

More accurate diagnostic methods of cardiovascular diseases such as blood tests or cardiac catheterisation are invasive and come with risks.

A team of scientists from the Nanyang Technological University (NTU), Ngee Ann Polytechnic and National Heart Centre Singapore (NHCS) co-developed a diagnostic tool powered by artificial intelligence (AI) that improves the accuracy of ECGs by up to 98.5 per cent. It uses a machine-learning algorithm that enables computers to learn from large volumes of past ECG data to fine-tune the overall analysis.

The project's co-lead, Prof Ng Yin Kwee, said, "Tests such as cardiac magnetic resonance imaging (MRI) or echocardiography are costly and require expert professionals on-site to assess the ultrasound and MRI images.

"Our tool aims to minimise risk by enhancing the non-invasive ECG method. Instead of 12 leads, our tool only requires two seconds worth of ECG reading with just one lead."



*Prof Ng Yin Kwee and a team of scientists from Ngee Ann Polytechnic, National Heart Centre Singapore, have developed a new tool that could lead to faster diagnosis of heart diseases.*

### AI-Enhanced Medical Diagnostics

The diagnostic tool was devised using a machine learning algorithm called 'Gabor-Convolutional Neural Network' (CNN).

It mimics the structure and function of the human brain, enabling computers to learn from past experiences like a human, but much more comprehensively and extensively.

Prof Ng, who teaches at NTU's School of Mechanical and Aerospace Engineering, said, "CNN is a form of deep neural network and is mainly used for image analysis. By combining it with a unique time-frequency technique that converts 1-dimensional signals into two-dimensional ones, the CNN can capture subtle changes in the time-frequency domain.

"What this means is that the tool can capture subtle changes in ECG signals, particularly minute variations in the ECG signal," he added.

This was observed during the project's pilot study examining the ECG signals and patterns from healthy individuals and patients with prevalent cardiovascular diseases. It involved 92 healthy individuals, seven patients with coronary artery disease, 148 patients with myocardial infarction and 15 patients with congestive heart failure.

Prof Ng said, "While reading ECG results manually is still the current benchmark for fast and easy diagnosis, our tool enhances that by mitigating human error and streamlining the process. It also provides essential information to medical practitioners, speeding up the overall process by four times.

"This AI tool would also benefit junior or non-specialist doctors when screening patients and arranging for appropriate downstream care."

**An AI For Collaboration**

While the results from the pilot study have been promising, the research team plans to start conducting further trials using a larger ECG database from local hospitals to validate its clinical use.

Prof Ng said that the tool is still in the early stages of research, and more real-world data is required for further validation.

"This is a promising start, and the AI tool has proved thus far to be fast, automatic, and accurate."

The joint research team welcomes further collaboration opportunities. "We will require further validation with data from clinics and hospitals. This is our next step for the tool, and we gladly welcome interested and like-minded organisations to collaborate with us and conduct further test-bedding and trials."

**// Our tool aims to minimise risk by enhancing the non-invasive ECG method. Instead of 12 leads, our tool only requires two seconds worth of ECG reading with just one lead.**

Prof Ng Yin Kwee  
Project co-lead

"As with all research projects, working alongside industry is key to ensuring the research remains grounded and relevant to society," he added.

Prof Ng added that he was fortunate to have the opportunity to serve as the Principal Investigator and Awardee for both the HealthTEC Seed Grant from Singapore Health Technologies Consortium and International Healthy Longevity Catalyst Global Innovator by the U.S. National Academy of Medicine.

He believes that such opportunities inspire academics to achieve more in science and engineering and hopes that his research work will serve as another example for others to strive towards research excellence.

**SPECIAL // ARTIFICIAL INTELLIGENCE**

# SHOPPING LIES IN THE AI OF THE BEHOLDER

**Associate Professor Hady Lauw** from the Singapore Management University explains how the ThriftCity framework makes sense of the multitude of products across different ecommerce platforms, providing consumers with the best offer.

A smart shopper would look at multiple e-commerce providers to compare prices, but the diversity of how products are listed with different model numbers, names, images, and specifications makes it challenging to find them at scale.

This is where an Artificial Intelligence (AI) framework of data mining and machine learning technology can help to make sense of the myriad of products.

Meet ThriftCity – a framework developed by Associate Professor Hady Lauw and his team from Singapore Management University (SMU)’s School of Computing and Information Systems.

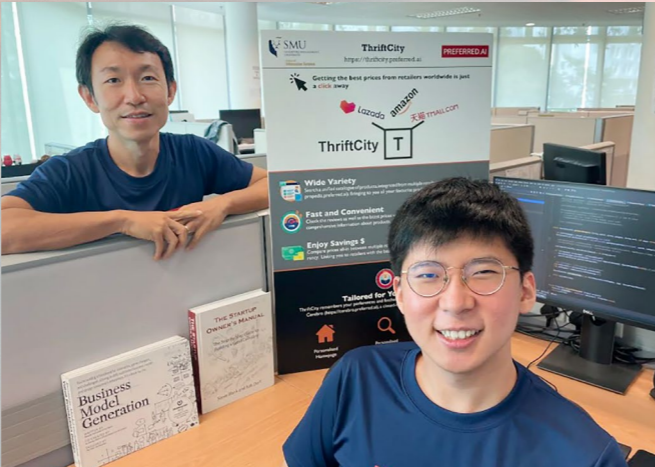
One key aspect of this technology is about collecting data all over the Internet, but products are often not identified by a single unique code, but instead have descriptors such as product names, brands and images.

Prof Lauw said, “There are billions of pages on the web and we can’t possibly go through all of it, so we have to build a crawling framework that is intelligent. This is where the AI comes in... where we train the framework to collect information efficiently.”

Training AI with Human Signals

Another aspect of the ThriftCity framework is determining when two products are the same product, and this is done by training the AI algorithms to make use of “signals that humans would use”- such as looking at the products’ appearance or its descriptions.

For example, to compare how the two products look, the AI system will require computer vision technologies to do image processing, or use Natural Language Processing technologies to identify the



Assoc Prof Hady Lauw (L) and Entrepreneur Lead of ThriftCity, Darryl Ong, will be looking at working with commercial partners in the South East Asia region in the coming year.

different descriptors in the product names, before comparing the products’ similarities through the use of machine learning.

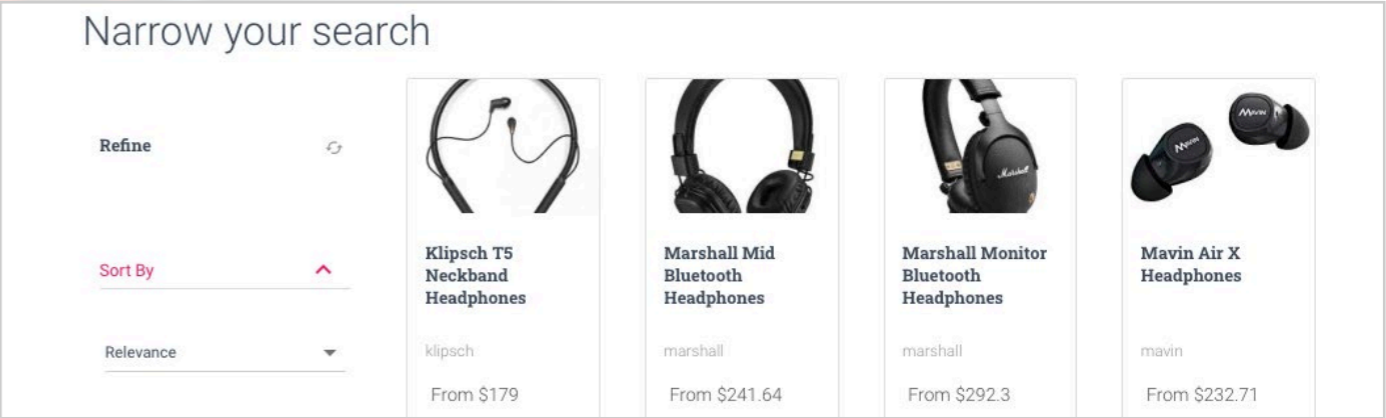
The team also designed the framework to specify the degree of confidence when determining when two products are similar.

“For instances where we are less confident, we can flag it and surface it to human labellers, who can then lend some supervisory judgment. In that case, this model will get better over time,” said Prof Lauw.

He also emphasised that such AI technologies are not developed to keep the human element completely kept out of the loop, but rather to reduce the effort required by the human, so that they can work on more products with the assistance of AI models.

Focus on Electronic Products

Currently, the ThriftCity platform has a focus on electronic products, specifically print cartridges,



The ThriftCity framework currently focuses on electronic products as they have the biggest price differences across ecommerce platforms.

headsets and smart watches, as they have the biggest price differences across platforms.

Prof Lauw explained that electronic products tend to have more unique datasets in terms of textual information such as model number or make, which makes it a good starting point to train the AI model. On the other hand, product domains like fashion may be more focused on the visual descriptors, and would require more vision and image resources.

ThriftCity was conceptualised as a research prototype around two years ago, and when Darryl Ong, a graduate from SMU’s School of Computing and Information Systems came on board last year.

He took up the role of Entrepreneur Lead and the team then started to consider commercialising the system. This was achieved with the support from the SMU Institute of Innovation and and Entrepreneurship.

Darryl said the team sees themselves as a technology player, so that ThriftCity will not be tied to a specific product domain. Although the technology is capable of sourcing products from anywhere reachable by

the Internet, the team will be looking to work with commercial partners in the South East Asia region in the coming year, where they are able to contribute to a growing e-commerce market.

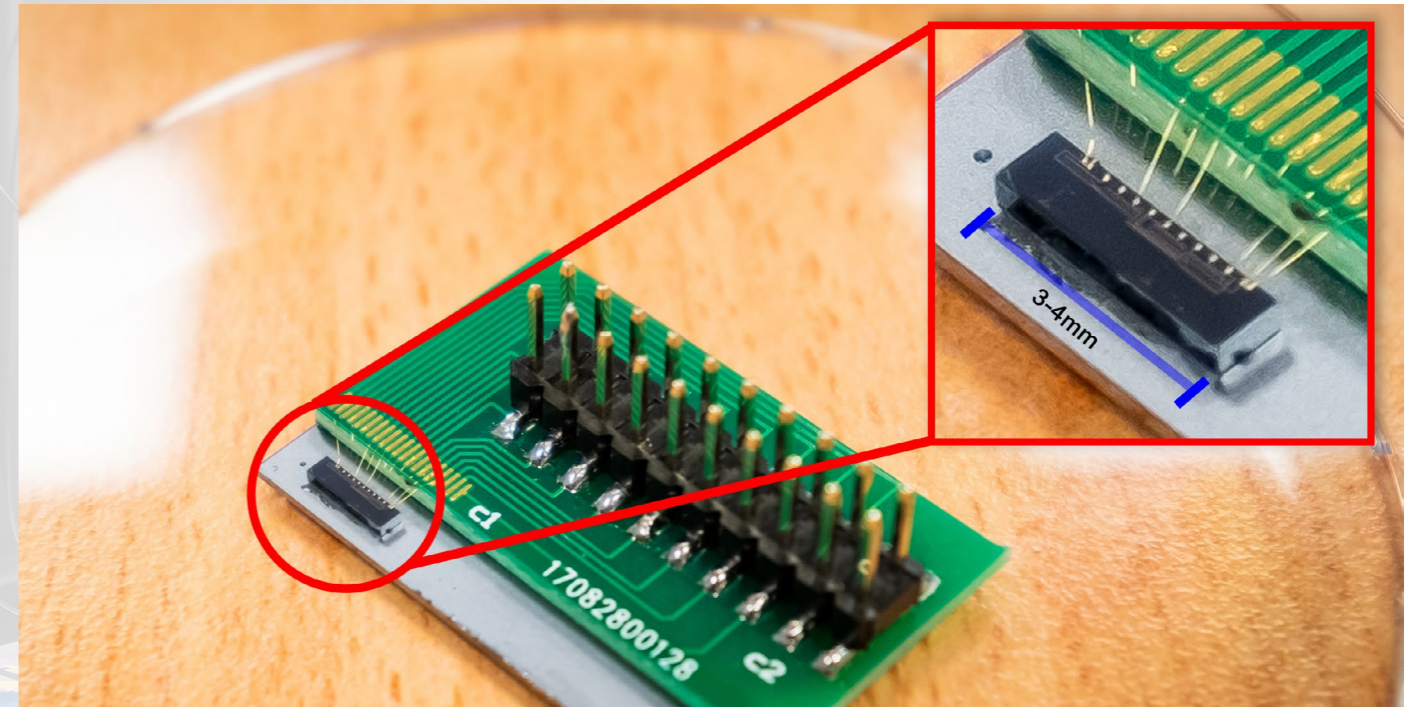
Instead of providing a direct service to consumers, he said that businesses that tap on their technology could find out how their competitor products are priced, and in turn price their products more competitively, to which consumers will still benefit.

Prof Lauw added that, “If things are progressing well in the next two years, we can revisit the idea of proving more consumer-facing services or products on ThriftCity.”

SPECIAL // QUANTUM

# QUANTUM CHIP 1,000X SMALLER THAN CURRENT SETUPS

Two scientists have developed a tiny chip that offers superior quantum-level security for more secure forms of communications. **Professor Liu Ai Qun** and **Associate Professor Kwek Leng Chuan** shares more about their cutting-edge innovation.



*Roughly about 3mm in size, the tiny chip developed by NTU scientists uses quantum communication algorithms to provide enhanced security.*

Scientists at Nanyang Technological University (NTU) have developed a quantum communication chip that is an incredible 1,000 times smaller than current quantum setups but still offers equally superior security quantum technology is known for.

Measuring 3mm, which is the size of a grain of rice, the tiny chip uses quantum communication algorithms to provide enhanced security compared to existing standards.

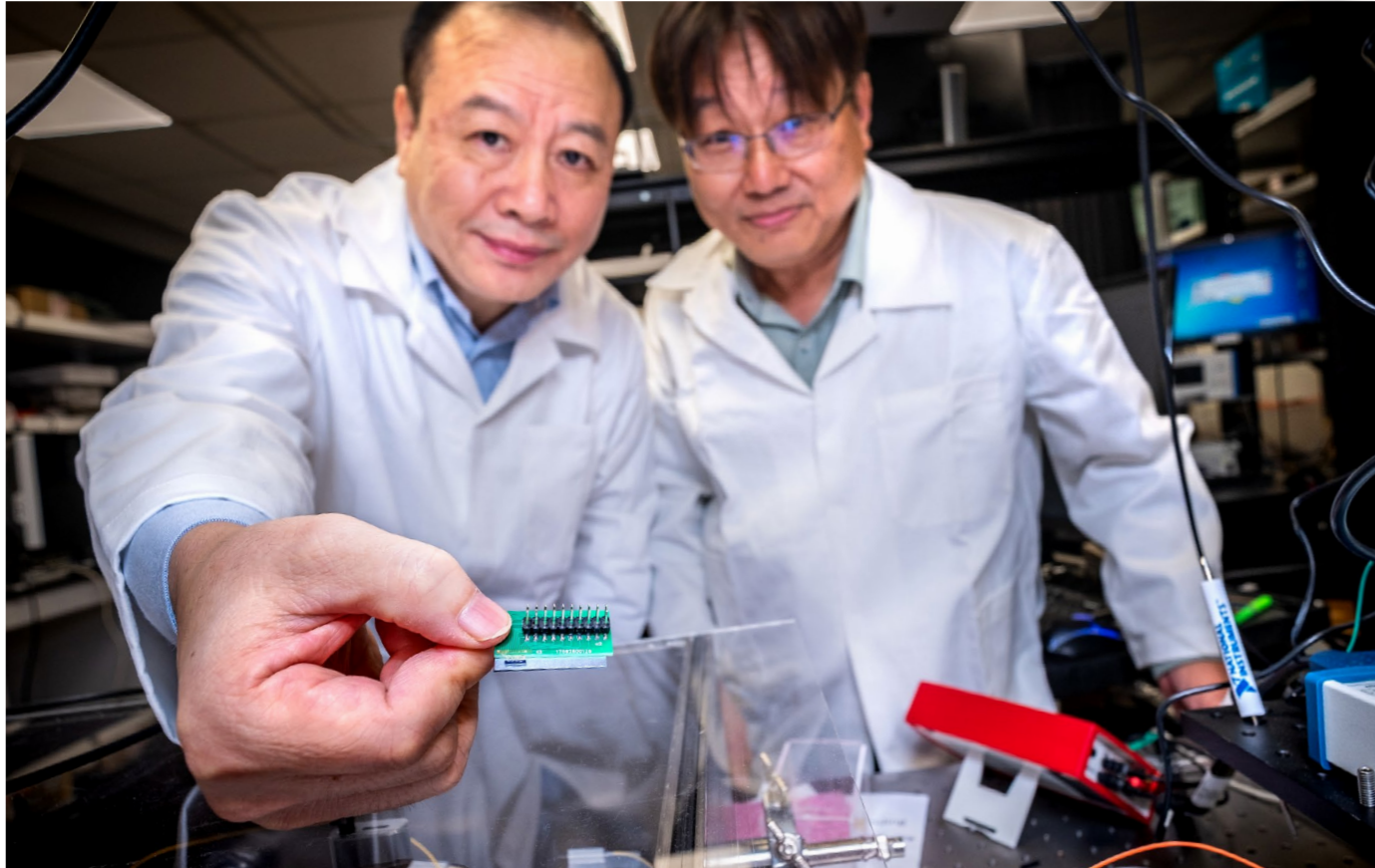
It integrates passwords within the information that is being transmitted to form a secure quantum key. After the information is received, it is destroyed along with the key, making it an extremely secure form of communication.

The chip requires 1,000 times less space than existing quantum communication setups that can be as big as a refrigerator or even take up the space of an entire fibre communications network.

This allows for more secure communication technologies that can be deployed in compact devices such as smart watches, smartphones, and tablets.

Project lead Professor Liu Ai Qun, Co-Director of the Quantum Science & Engineering Centre (QSec) at NTU, said, "Almost all digital platforms and repositories require users to input their passwords and biometric data, and as long as this is the case, it could be eavesdropped on or deciphered."

Images: NTU



(L-R) NTU Prof Liu Ai Qun and Assoc Prof Kwek Leong Chuan showing the tiny 3mm quantum communication chip embedded on the bottom right of the green circuit board, which is 1,000 times smaller than current setups and provides almost unhackable levels of encryption.

Quantum technology eliminates this as both the password and information are integrated within the message being sent, forming a ‘quantum key’.”

The chip operates at a 1550 nm wavelength and includes amplitude and phase modulators that generate a series of quantum coherent states; information is encoded on a 1–10 MHz sideband.

The innovative chip lays the foundation for better

encryption methods for online transactions and electronic communication.

Project co-lead Associate Professor Kwek Leong Chuan, Co-Director of QSec, explains that quantum communication works by using randomised strings of code to encrypt the information, which can only be opened by the intended recipient with the correct ‘key’.

//

**This is the future of communication security, and our research brings us closer to quantum computing and quantum network.**

Prof Liu Ai Qun  
Co-Director of QSec at NTU

There is no need for additional passwords or biometric data to be transmitted, which is the standard practice in current forms of communication.

“It is like sending a secured letter. Imagine that the person who wrote the letter locked the message in an envelope with its ‘key’ also inside it. The recipient needs the same ‘key’ to open it. Quantum technology ensures that the key distribution is secure, preventing any tampering to the ‘key’”, said Assoc Prof Kwek, who is also a physicist at NTU’s National Institute of Education.

**Military-grade communication tech, made cost-effective**

The world’s biggest tech companies such as Google and IBM are racing to develop quantum supercomputers that would revolutionise computing at speeds now inconceivable.

One highly anticipated strength of quantum technology lies in cryptography, the art of secret communication.

With the proliferation of Internet services, emails and messaging platforms such as WhatsApp, Facebook, Skype, Snapchat, and Telegram, have created secure channels for communication – what is known as “classical channels”.

In contrast, “quantum channels” that carry information have security protocols that are integrated into encrypted data. Each channel is uniquely different from the other, reducing or even eliminating the risk of data being intercepted or leaked during transmission.

Simply put, quantum technology does not require additional transmissions of passwords or biometric data that is necessary in “classical channels”.

This eliminates the risk of interception or information being leaked, creating almost unbreakable encryption.

The quantum chip developed by the researchers will be cost-effective as it uses standard industry materials such as silicon, which also makes it easy to manufacture.

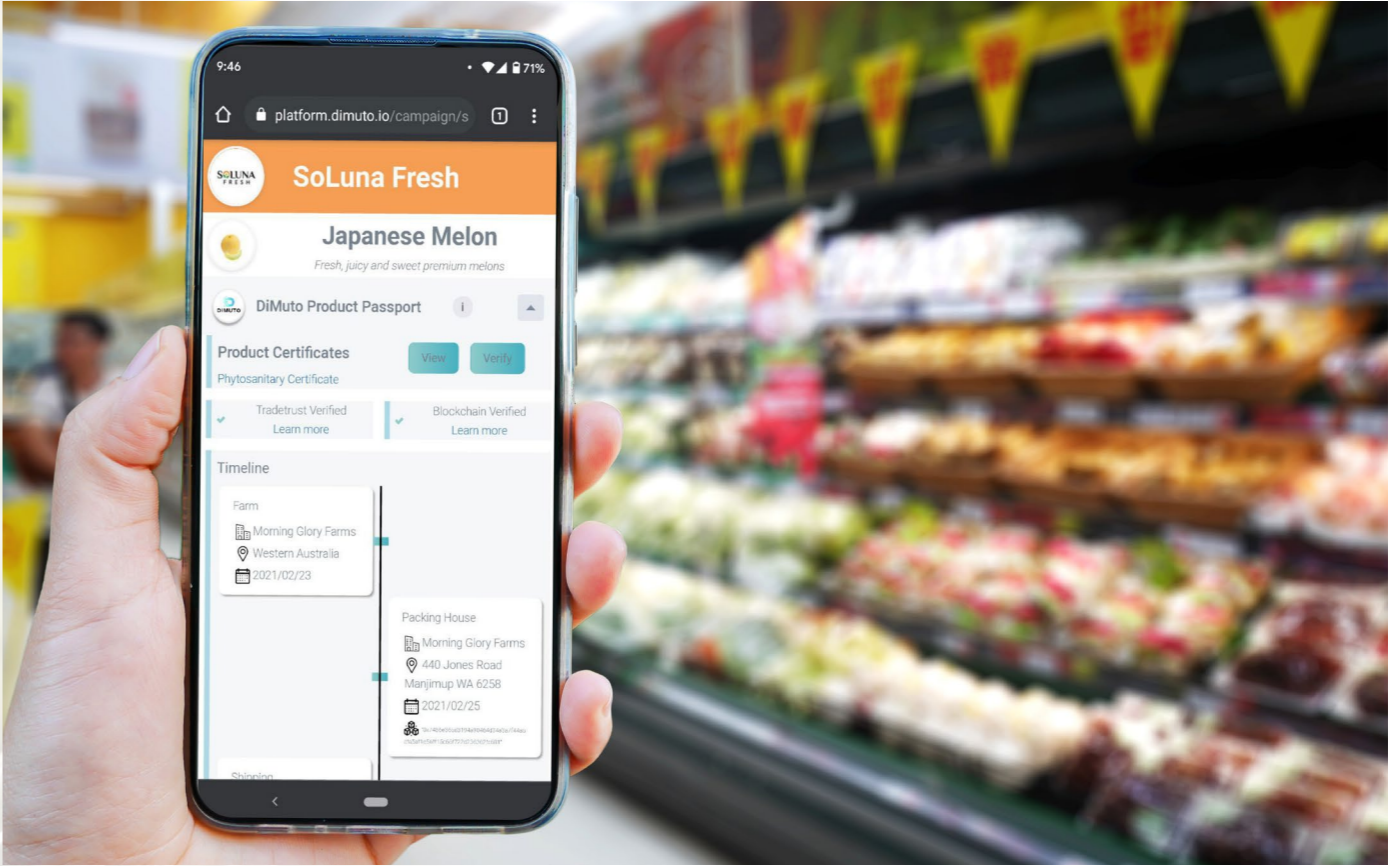
Prof Liu said, “This is the future of communication security, and our research brings us closer to quantum computing and quantum network. It will help spark the creation of ‘quantum-channels’ networks with quantum chips, as well as enhance digital services such as online financial portals of banks and digital government services.”

The NTU team is now looking to develop a hybrid network of traditional fibre optical communication systems and quantum channels network systems. This will improve the compatibility of quantum technologies that can be used in a wider range of applications such as internet connectivity.

SPECIAL // BLOCKCHAIN

# DIGITALISING THE AGRI-FOOD SUPPLY CHAIN

Singapore-based blockchain start-up DiMuto digitalises the agri-food supply chain to help traders ensure authenticity and transparency in record-keeping while enabling consumers to know where their food comes from through unique QR codes. **Mr Gary Loh**, CEO and Founder of DiMuto, gives a sneak peek into their tech that enables this.



By simply scanning the DiMuto QR code on food products like fresh fruits and produce, consumers are brought to DiMuto SMART Marketing Product Page, where they can now view the DiMuto Product Passport.

Most fruit and produce on sale at Pasir Panjang Wholesale Centre comes with QR code stickers that link to their origin, packing location and product certificate. These were developed by DiMuto, a Singapore-based blockchain start-up, which is also digitalising the supply chain of some traders at the market.

Mr Gary Loh, CEO and Founder of DiMuto, said they are essentially an agri-food trade solutions platform. "DiMuto tracks the flow of goods from farm to table,

and correspondingly, the flow of money as well. This allows us to have a holistic view of the whole supply chain, and our platform helps to organise all the complex data securely."

He added, "Traders can capitalise on such data through marketing, market access or trade financing, to name a few."

DiMuto uses blockchain technology to tag, track and trace foods, and the data is processed using

Images: DiMuto



**// I didn't set out to build a dream software through DiMuto, I just built software to get rid of nightmares that I faced in the past in my work, hoping to make the trade ecosystem a better place to do business.**

Mr Gary Loh  
CEO and Founder, DiMuto

blockchain. This involves decentralising digital databases containing information about transactions or contracts that cannot be altered and visible to everyone throughout the supply chain.

Mr Loh explained that this is useful to the agri-food industry, which uses the 'pen and paper' administrative processes. Such paper-based records make it nearly impossible to trace products from end to end.

"The agri-food industry is still not accustomed to digital technologies, so we do not need to go so far as to dwell into cybersecurity and what not," he said. "We digitalise the process by adding blockchain to the system, enabling traders to share data. Blockchain technology also addresses security concerns on sharing the data."

Mr Loh also stressed that not every trader or merchant within the ecosystem needs to digitalise or be on the same platform for the blockchain solution to work.

### End-to-End Supply Chain Visibility

All the transacted and recorded data is encrypted and loaded onto a distributed ledger, enabling traders and merchants to create trade contracts, monitor

packing status, and confirm product receipts.

The increased transparency and authenticity help solve one of the most significant issues the agri-food industry faces – access to traditional bank financing.

"Securing funding from banks has always been a challenge facing the agri-food industry. Such disconnected visibility in the supply chain cause industry players to pay a high cost for trade disputes, food safety breaches and wastage," said Mr Loh.

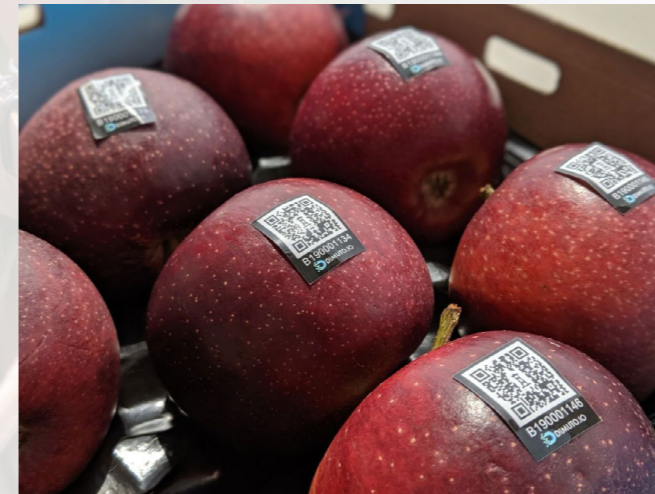
He explained that the principle behind tapping on blockchain tech in supply chain management is the ability to use something immutable. Once the data is captured, it includes a timestamp that provides a form of authenticity.

"This is especially useful for the agri-food industry as a lot is happening on the ground, and most of it is not captured as most stakeholders do not have the visibility of knowing what actually happened or who made a mistake. This helps provide a high level of visibility, transparency and trust, to the various stakeholders along the supply chain."

One of DiMuto's solutions also provides consumers with traceability information for food as it moves through the supply chain by capturing data at key

stages. Each fruit and carton are assigned a digital identity using QR codes.

"For example, working with our partner Newton Orchards in Western Australia, every apple was tagged with a DiMuto QR code that can be scanned by consumers with any smartphone. They will be directed to a product page that gives them easy access to traceability information and product origin."



*Fresh apples with QR codes developed by DiMuto using Blockchain technology.*

### Supporting the Trade Ecosystem

DiMuto is on track to become a trading platform that provides a holistic view of the supply chain, including the movement of finances. Mr Loh explained that there are instances where payments are lost in transition.

"One of the key problems in trade is the paperwork required to authenticate transactions, and worse, lost or delayed paperwork causing even further delays in the shipment and payment."

"We have seen cases where a trader sent payment

to Chile or Peru, for example, but somehow the payment was not received there, or there is a delay in the process, or it is stuck with the bank, and so on. So a stakeholder having visibility on where and what they are financing is vital to avoid fraud and establish trust."

Moving forward, Mr Loh said that DiMuto will continue to innovate and find better ways to tackle food waste, enhance food visibility and address sustainability.

"I didn't set out to build a dream software through DiMuto, I just built software to get rid of nightmares that I faced in the past in my work, hoping to make the trade ecosystem a better place to do business."

SPECIAL // CYBERSECURITY

# FOSTERING CYBERSECURITY CO-INNOVATION

**Dr Vivy Suhendra**, Executive Director of the Singapore Cybersecurity Consortium, shares her mission to link industry, academia and government agencies on a seamless platform for engagement in cybersecurity.



*Dr Vivy Suhendra, Executive Director of the Singapore Cybersecurity Consortium*

The Singapore Cybersecurity Consortium was established as a national engagement platform for the research community, industry, and public agencies to discuss and collaborate in technology adoption and research translation to solve cybersecurity challenges.

It is funded under the National Cybersecurity R&D (NCR) Programme and located at the National University of Singapore (NUS) since 1 September 2016.

The Consortium's primary role is to bridge the different sectors in driving the flow of innovations from research to market. Companies and agencies face varying challenges in the well-established trinity of cyber protection aspects in the evolving cyber landscape.

This range from having an adequate cybersecurity workforce (People) and establishing resilient protocols for vulnerability detection and incident response (Process), to deciding on and investing in the security mechanisms that fit their needs and knowing how to effectively integrate and utilise them (Technology).

Providers of security technologies and services, who work with the organisations to meet these needs, in turn face challenges in keeping up with new malware or technological trends that bring with them a suite of unfamiliar attack surfaces.

On the other hand, high-quality cybersecurity research is conducted in various universities and research institutes across Singapore. Many of these efforts have produced cutting-edge outcomes in fields such as vulnerability detection and automated repair in software, privacy-preserving computation, cyber-physical system resilience, and many others.

While a good proportion of these can solve the practical problems faced by the industry, they exist in varying stages of commercial readiness and varying ease of accessibility for those outside the scientific community.

The Consortium serves to bridge this gap from both directions. Firstly, by helping companies and agencies navigate the various research and technology developments. Secondly, by exposing researchers to industry and market perspectives. This could drive the maturing of existing research results and inform new research directions to address pertinent problems on the ground.

In the Consortium's thematic Special Interest Groups, members from all sectors share technology updates and discuss in depth about newly discovered threats,

challenges in operating environments, pain points with existing technologies, and ideas to resolve these.

In some cases, it may involve appropriate technology applications, managing human factors, and designing regulations or incentives.



The Singapore Cybersecurity Consortiums conducts various activities such as workshops for collective brainstorming, collaborative effort, or partnerships towards solutions.

Public agencies have also used the platform to solicit inputs and understand on-the-ground challenges to help shape future initiatives.

Through these interactions, researchers and companies identify common unresolved problems, and form partnerships for joint research and co-development, some of which can be funded by the Consortium's seed grant.

The seed projects may take existing research outcomes or those still in the pipeline, iron-out operational and deployment issues, and mature the technologies to a ready state for deployment at the agencies or commercialisation by the companies.

With less well-explored challenges, the seed projects may also conduct new research, with domain expertise input from the companies or agencies, with a view

of taking the resulting proofs-of-concept to compete for larger NCR grants beyond the Consortium – such as those administered by the National Satellites of Excellence in Cybersecurity, which are similarly funded by the NCR Programme.

Supporting Innovative Projects

The Consortium has funded fourteen seed projects to date.

One pertinent technological trend addressed in the ongoing works is the rising adoption of Artificial Intelligence (AI): one project looks at detecting adversarial perturbations that may compromise AI-based decision systems, while another, taking the other direction, develops an AI-based technique for security evaluation of hardware platforms.

Another prevalent concern is the need to balance privacy requirements with data usability, which is tackled by two projects in different settings: collaborative analysis of sensitive data such as medical research, and data management in third-party clouds.

In an interesting intersection of these domains, a recently awarded project focuses on quantifying and optimising data privacy used for AI-based analytics in an Internet-of-Things system.

These collaborations, which are first nurtured through interactions on the Consortium platform, strengthen the ecosystem cohesion by enabling the flow of talents from universities to the industry, where students are trained through working in the projects and subsequently recruited into the industry.

Likewise, projects that utilise testing and experimentation support from NCR-funded testbeds

**“ Sustaining such a multisectoral cybersecurity community engagement certainly requires a continuing effort – an effort which needs to be dynamic as well, as the community itself grows and evolves, and as new challenges surface after initial ones are overcome.”**

Dr Vivy Suhendra  
Executive Director, Singapore Cybersecurity Consortium

– including the National Cybersecurity R&D Lab (NCL) and iTrust Testbeds – further enrich the knowledge base by making their outcomes, such as malware database and virtual honeypot setups, available on those shared infrastructure.

This enables the community to reuse and build upon the studies, leading to more innovations.

As project outcomes are extended in other grants or deployed by other organisations and agencies, longer-term and new partnerships are also formed.

Sustaining such a multisectoral cybersecurity community engagement certainly requires a continuing effort – an effort which needs to be dynamic as well, as the community itself grows and evolves, and as new challenges surface after initial ones are overcome.

Grooming Next-Gen Cybersecurity Talent

As its future work, the Consortium hopes to tackle the prevalent last-mile gap in research translation efforts.

Specifically, nurturing skilled manpower with both an in-depth understanding of cutting-edge research results and the engineering proficiency to further develop and integrate the research prototypes and tools into operating environments in companies and agencies.

This work is often beyond the scope of typical research projects yet is not always practical for most organisations to invest in, and nor is it always feasible to have dedicated spin-offs from the research teams to take things further.

Coordinating the training and manpower efforts to perform this essential work is thus envisioned to widen the innovation bandwidth, help more research outcomes progress to deployment, and answer more cybersecurity challenges.

■ COMMENTARY // DEEP TECH

# DEFINING DEEP TECH'S NEXT CHAPTER

Deep tech — the term for technologies not focused on end-user services that includes artificial intelligence, robotics, blockchain, advanced material science, photonics and electronics, biotech and quantum computing — has been an identified category for investment as long as the tech industry itself. **Dr Lim Jui**, Chief Executive Officer of SGInnovate sheds light on this topic and Singapore's relationship with the deep tech industry.



*Dr Lim Jui, CEO of SGInnovate.*

## What is Deep Tech?

Deep tech is a catchy term without a formal definition. It means different things to different people.

At SGInnovate, our “house” view is as follows: deep tech flows from deep science and deep thought. It demands a high degree of specialisation both at the point of invention and at the point of application, yet it is almost always multidisciplinary.

AI is the exemplar of this unique combination of depth and breadth. It's not just about clever coding; it also takes reference and understanding of “distant” fields of study in psychology, neural networks, linguistics, for example.

Similarly, although one could argue to a lesser extent, the development of mRNA therapeutics goes beyond

molecular biology to demand a deep understanding of medicine, immunology, pharmacology, and logistics.

At a working level, we will look at emerging – and potentially platform – technologies arising from relatively recent research with the potential for strong intellectual property protection.

“Relatively recent”, is of course, context-sensitive. For digital technologies, this could be a few years. For biomedical technologies, it can be significantly longer, stretching to a decade, sometimes more – again, using mRNA therapeutics as an example, they did not just “show up” in response to the pandemic but represent the culmination of more than a decade of work.

SGInnovate has played an important role in raising awareness of deep tech and is at least partly responsible for its currency in Singaporeans' everyday conversations on business and technology. Many investors who had previously been deterred by the complexity and cost of deep tech investments are now flocking to it, recognising its potential for creating new vistas of economic growth de novo.

Whether it is the commercial space industry, or electric vehicles, or cybersecurity, to name but a few, deep tech is creating whole new industries where none existed before, serving as a critical engine of economic growth and new, high-value job creation. The latter is especially relevant for Singapore in the global race to attract and retain talent.

Deep tech's biggest draw, however, is its problem orientation. Increasingly, it is recognised for its potential to solve challenging problems that transcend political boundaries – the pandemic response being

a case in point. In fact, research suggests that 97 per cent of deep tech ventures contribute to at least one of the UN’s sustainable development goals.

Targeting such global challenges offers deep tech startups the opportunity to look beyond local constraints and scale globally while generating significant economic value.

Imagine the multitude of ways food production could be transformed if we combined AI with additive manufacturing, or the ability to turn the body into a bioreactor, manufacturing its own vaccines and medication. The potential is limitless, and the impact will be tremendous.

**Our Deep Tech Report Card**

Thanks to prudent long-term investments made in Singapore’s RIE ecosystem, our foresight has enabled our innovation ecosystem to grow, even amidst increasing competition and disruption.

Over the past few years, the landscape has changed dramatically and many notable home-grown deep tech companies have emerged, including Singapore’s first deep tech unicorn, Nanofilm, whose record-setting listing was Singapore’s biggest in recent years.

As a further indication of confidence in this growing momentum, Temasek also recently announced an annual commitment of SGD 1 billion specifically for deep tech across a wide range of domains.

Many of the innovations developed by our local deep tech startups already play an active role in making daily life healthier, more secure, and sustainable.

For instance, DiMuto’s work to digitise produce supply chains is improving the visibility of our global trade

**Thanks to prudent long-term investments made in Singapore’s RIE ecosystem, our foresight has enabled our innovation ecosystem to grow, even amidst increasing competition and disruption.**

Dr Lim Jui  
CEO, SGInnovate

networks and creating new economic opportunities for farmers and agrifood companies.



*Durians with QR codes developed by DiMuto using Blockchain technology provides increased traceability and authenticity to the agri-food industry.*

Meanwhile, UNL’s micro-location technology is building an ‘Internet of Places’, turning any location into a unique address, potentially connecting billions to the global digital economy.

Others like Shiok Meats and Biofourmis go even further to offer us a preview of things to come, shaping how we eat, stay healthy and connect with each other.

These are just a handful of the many Singapore-born deep tech startups cementing our country’s

reputation as a place where ideas are birthed, and boundaries are pushed.

While Singapore has made massive strides in growing our startup and innovation ecosystem in recent years, we must look towards building an entrenched, thriving, and respected deep tech economy.



*Shiok Meats, the world’s first cell-based crustacean meat company based in Singapore, showcased the first ever cell-based lobster meat in Nov 2020.*

If it is to become the engine of future growth that we want it and need it to be, we need to step up investments into commercialising our rich substrate of research across our IHL’s and research institutes in order to extract full economic value and societal impact from it.

**Sustaining our Deep Tech Momentum**

Time and time again, startups continue to prove to be the best transducers of deep tech commercialisation. Theirs is the role of a keystone species in an ecosystem – one whose existence is core to the vibrancy and growth of this deep tech Economy.

Yet despite their rise in profile, deep tech startups continue to face a number of challenges that stand

in the way of their full potential, whether it’s the need for patient capital or the unequal levels of interest from investors across different areas of deep tech.

As a relatively new player, SGInnovate has had the unique opportunity to reimagine how these challenges can be addressed. Together with our partners, we’ve engineered a ‘triple helix’ strategy to support deep tech innovators – adopting a long-term approach to investing in high-potential emerging technologies, bridging critical talent gaps and building a thriving ecosystem that fuels collaboration and partnership.

This integrated network of resources combines the strengths of a strategic fund like SGInnovate, with those of VCs, and other public and private partners, while simultaneously looking at startups’ holistic needs beyond funding.

As each partner lends their specific expertise or creates new opportunities for test-bedding and market access, this symbiotic and mutualistic relationship forms the backbone of our deep tech economy and offers a fertile ground for research translation and the development of emerging technologies.

Our relationship with deep tech will continue to grow and evolve alongside the ecosystem’s needs as we dive deeper into its potential to address some of our biggest existential challenges. Only by remaining closely attuned to these needs and collaborating will we be able to help our much-valued startups scale and usher in the deep tech economy.

■ FEATURE // DEEP TECH

# PREDICTING THE NEXT VIRAL FOOD TRENDS

Co-founder and CEO of Ai Palette, **Somsubhra GanChoudhuri**, shares how artificial intelligence and machine learning are used to help companies identify and predict upcoming food trends.



Images: Ai Palette

Peanut butter beer – this may or may not sound appetising to you. However, artificial intelligence (AI) technology has shown that this might just be the town’s next “in” flavour.

Ai Palette, a local foodtech startup, developed a predictive analytics platform that can identify and analyse food trends in a particular market to determine what makes a certain ingredient or flavour popular and even predict how long that growth might last.

The platform can also predict what types of food or ingredients are up and coming, which can help companies create products to meet the latest needs of consumers.

“For instance, consumers recently started looking at how to boost their gut health. Companies using Ai Palette will then be able to see and understand this trend in real-time, and its predictive analysis can help them make product decisions with confidence,” Ai Palette’s co-founder and CEO, Somsubhra GanChoudhuri shared.

Prior to starting Ai Palette in 2018, GanChoudhuri had worked in the food industry for over seven years, where he saw how new food products are traditionally created.

“If we were to create a new coffee flavour for the Indonesian market, we would have to fly down to Jakarta, visit the cafes and supermarkets, taste the coffee served there or see what kind of products are available, write down our notes, before coming to a decision or recommendation.”

These market visits took up a lot of time and costs, and often included the biases of people conducting the visits. “About 85 per cent to 90 per cent of new



Co-founders of Ai Palette - Himanshu Upreti (L) and Somsubhra GanChoudhuri.

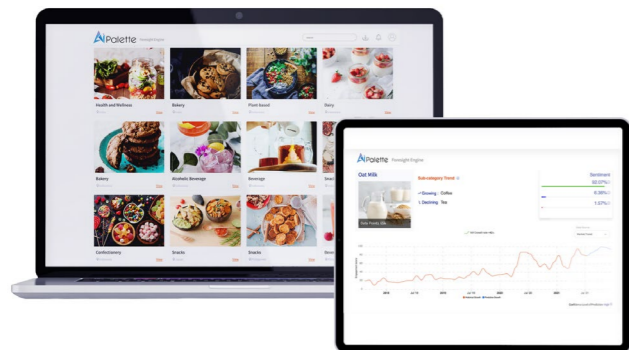
innovations fail in the industry, which is a very high rate of failure,” shared GanChoudhuri.

While mulling over ways to improve such innovative approaches, GanChoudhuri noticed there is already a lot of data available publicly online.

## Identifying New Food Trends

Together with his co-founder Himanshu Upreti, who has a background in big data analytics and advanced machine learning, they worked on using AI to draw meaningful correlations between these large amounts of data points.

The platform currently collects data from multiple



*Ai Palette developed a predictive analytics platform to identify and analyse food trends in a particular market and even predict ingredients or flavours that might be popular.*

sources such as social media, restaurant menus, online recipes and retail products available on search engines. Natural Language Processing (NLP) algorithms are then used to decipher the data before using AI and machine learning to identify trends and predict a food product that may go viral.

So how does Ai Palette identify a trend that has not appeared yet?

GanChoudhuri explained that their system uses the named-entity recognition in AI to identify new words or terms in the data pool. The algorithm then tracks to ensure that there is a significant volume of such data points to classify it as a trend. For example, “dalgona coffee” became a viral hit on social media last year, when most people would not have heard of the word “dalgona” before.

“There is a threshold for every market that the data has to cross before we can say with confidence that this is a new trend. This includes the number of data points around the particular trend, how it has evolved in the past, and how it is manifesting itself in menus and other products today.”

## Supports 15 Languages

Ai Palette’s ability to support multiple languages is also one of its most significant differentiating factors from other trend prediction AI platforms. It currently supports 15 languages, including Asian languages like Mandarin, Japanese, Vietnamese, and European languages like Spanish, French and German, with plans to add even more.

GanChoudhuri said that as English is not a primary language in Asia, they “started out with the hardest part of the puzzle” by building a language-agnostic algorithm that can be trained to analyse new languages, instead of having to use a translation tool that may be less accurate.

Ai Palette just announced that it raised US\$4.4 million in its Series A funding in August, and aims to expand beyond Asia. They will be setting up offices in the United States and Europe these two years, and plan to launch more products to help clients with product innovation.

Sharing some interesting trends that Ai Palette had predicted so far, GanChoudhuri said, “As a result of the pandemic, people have been looking for food products to improve mental health, such as those that aid in better sleep. This is a market that is currently underserved, so we can expect to see more of such products in the next year or two.”

He also highlighted that peanut butter, a common ingredient in the breakfast and confectionery space, is now making waves in the alcoholic beverages section.

“Be it peanut butter whiskey or beer, you’ll be surprised to see how many of such products are in the United States market now!”

## FEATURE // DEEP TECH

# INTELLIGENT ROBOTS ON THE MOVE

Co-founder and CEO of Movel AI, **Abhishek Gupta**, explains how their software can enable more effective navigation and faster deployment of robots.



Be it a robot that cleans a shopping mall, serves food in a restaurant, or transport goods in a warehouse, it will require a navigation software backend to control its movement precisely in different environments.

Movel AI, a local deep-tech startup, provides such software solutions to various hardware robotics companies.

Their software can enable more effective navigation and faster deployment of robots, which is three times more accurate, five times faster and 80 per cent cheaper than current standards.

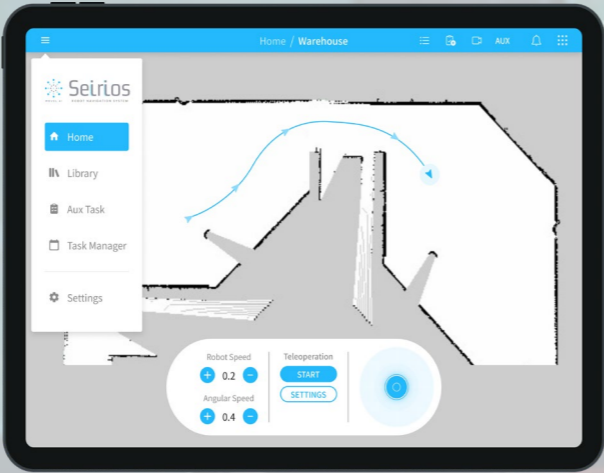
Co-founder and CEO Abhishek Gupta shared that many robots currently cannot navigate in surroundings autonomously.

To overcome this, Movel AI, developed an advanced system that combines sensor fusion and vision, machine learning and artificial intelligence technology, allowing robots to “see and react” to their surroundings the way humans do.

He added that their software system is compatible with any robots using the Robot Operating System (ROS), and around 80-90 per cent of the robots worldwide are currently using ROS.

Companies also can choose any light detection and ranging (LiDAR) sensors, cameras, or motor encoders in the market to assemble their robots. Movel AI’s system can collect the data from all these different components to give a single output.

“This makes it much easier for the companies to choose what kind of sensors and parts their robots are compatible with. Instead of using one high-end LiDAR, they can use additional cameras to



Movel AI's Seirios Robotic Navigation System dashboard where the robot's position is represented by a triangle in the map with a control panel.

complement the sensors, thus bringing down costs and reducing deployment time,” said Abhishek.

The system can achieve navigation accuracy of less than 5cm with recommended sensors even in dynamic environments.

**Easy to Use**

As part of making robot navigation seamless, Movel AI made it simple and convenient for users to operate robots through their system.

Abhishek said that users do not need to have prior knowledge of ROS or other deep-tech expertise; they can “simply take out their phone, tablets or PC, and tell the robot to do a task with one click”.

For instance, after a hotel client has integrated Movel AI software with a service robot, they can easily use their mobile device to connect to the robot through WiFi or the local network. Through a few simple clicks

Images: Movel AI



Co-founder and CEO of Movel AI, Abhishek Gupta.

of a button, they can customise the robot’s navigation route to various locations.

Clients can also use the same interface to instruct the robot to complete specific tasks, such as mapping an area to clean.

“It is like training a kid, telling (the robot) this is room A, room B, room C, which it will learn and automatically navigate around after you taught it once,” Abhishek explains.

Other than the service industry, Movel AI also supports the cleaning, healthcare and construction industries. For example, during the COVID-19 pandemic, hotels can use their software to task robots to deliver food to quarantine rooms or serve food in restaurants to minimise contact.

Moving forward, Movel AI envisions itself to be the software provider for robotics companies in

Singapore. Abhishek hopes to partner with more robotics companies locally.

By integrating their software, different companies’ robots of various uses can easily communicate when placed in the same environment, fostering an ecosystem of robots.

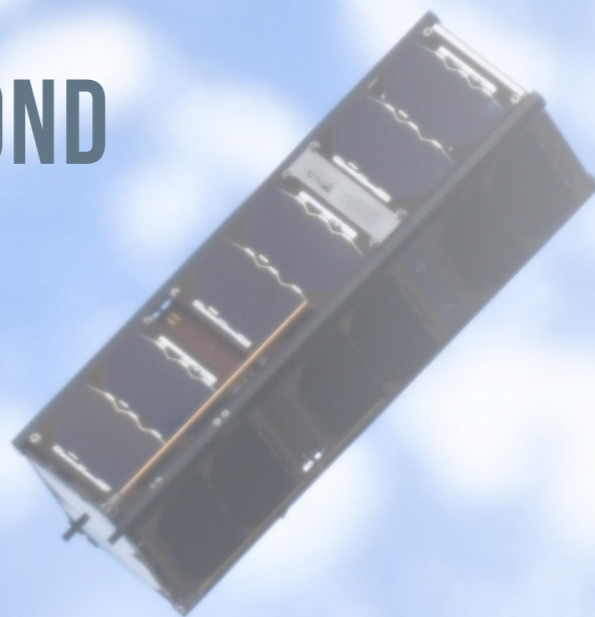
He said, “Robotics is progressing, and I think that in the next 15 to 20 years, each individual person will be surrounded by at least two or three robots, which is the scale of robotics in future.”

“I believe this is the best time to be in deep-tech and robotics because this field is progressing at a very exponential rate.”

■ FEATURE // DEEP TECH

# TO QUANTUM AND BEYOND

Defining Singapore's nascent quantum communications industry, **Mr Chune Yang Lum**, CEO & Co-founder of SpeQtral, explains how his startup is preparing for the quantum computing revolution by testing it in space.



Images: SpeQtral



CEO and Co-Founder of SpeQtral, Mr Chune Yang Lum.

Quantum computing is a game-changing technology that weds the most mystifying subject in all the sciences (quantum mechanics) with the most impactful force in the industry today – computing.

However, this is one side of the coin as quantum computers also introduce cyber threats. For data communications requiring the highest security, such as in government communications, power grids, datacentres, and financial institutions, steps must be taken immediately to mitigate this risk.

This is where the next-generation model of secure communication comes in: quantum communications.

Enter SpeQtral: a Singapore-based startup developing a satellite-based Quantum Key Distribution (QKD) system for quantum communications and cybersecurity.

Mr Chune Yang Lum, CEO & Co-founder of SpeQtral, highlights that understanding and implementing QKD is as essential as advancing quantum computing technologies.

He said, “The emergence of quantum computers will spur breakthroughs that impact various industries, from pharmaceuticals to advanced materials. It would be a matter of time before such technology is used for malicious activities.”

“At SpeQtral, we have made it our mission to deliver tamper-proof and computationally uncrackable encryption keys for security against present and future advances in computing.”

Mr Lum explained that generating these keys involves using the quantum properties of light particles known as photons.

“If an eavesdropper attempts to intercept these photons between the sender and the recipient, the quantum properties would be disrupted, and the parties would know that the key distribution has been compromised.”

## Going Beyond the Limitations of Earth

Today's internet already uses photons to carry data through optical fibres, he added. “QKD can be implemented on existing optical fibre infrastructure, but it is typically limited to about 50 to 100 kilometres due to optical losses.”

“So, for example, if you want to send keys between Singapore and its embassy in the United Kingdom, there is no practical method to perform QKD via the undersea fibre optic network between these two nodes. And hence, we looked beyond earth.”

Formerly from the Centre for Quantum Technologies (CQT), some of SpeQtral's staff were part of the core team that launched a nanosatellite 'SpooQy-1' in 2019. They tested QKD capabilities that include demonstrating 'quantum entanglement in space.'

Mr Lum said, "The objective may be simple, but it is challenging to control and maintain quantum states in space."

Testing in that environment involves surviving challenges such as vibrations from the rocket launch and temperature fluctuations. The next step would be to test the transmission of quantum communication signals between the satellite and ground stations."



SpooQy-1 is a 30x10x10-centimetre nanosatellite weighing 2.6 kilograms. It acts as a precursor to future satellite-to-ground QKD missions and capabilities. Since the launch, SpeQtral has assisted in the operations of the satellite alongside CQT.

SpeQtral is now working towards sharing QKD keys across the globe between multiple nodes. This next phase is essential for the industry. It demonstrates potential commercial capabilities so that users can plan to integrate such technology into their communication networks.

**Collaboration that Drives Innovation**

Mr Lum highlighted that quantum technology is a relatively young field from a commercial standpoint. He underscored that CQT is primed to develop new quantum technologies, given its extensive R&D experience in this field since 2007.

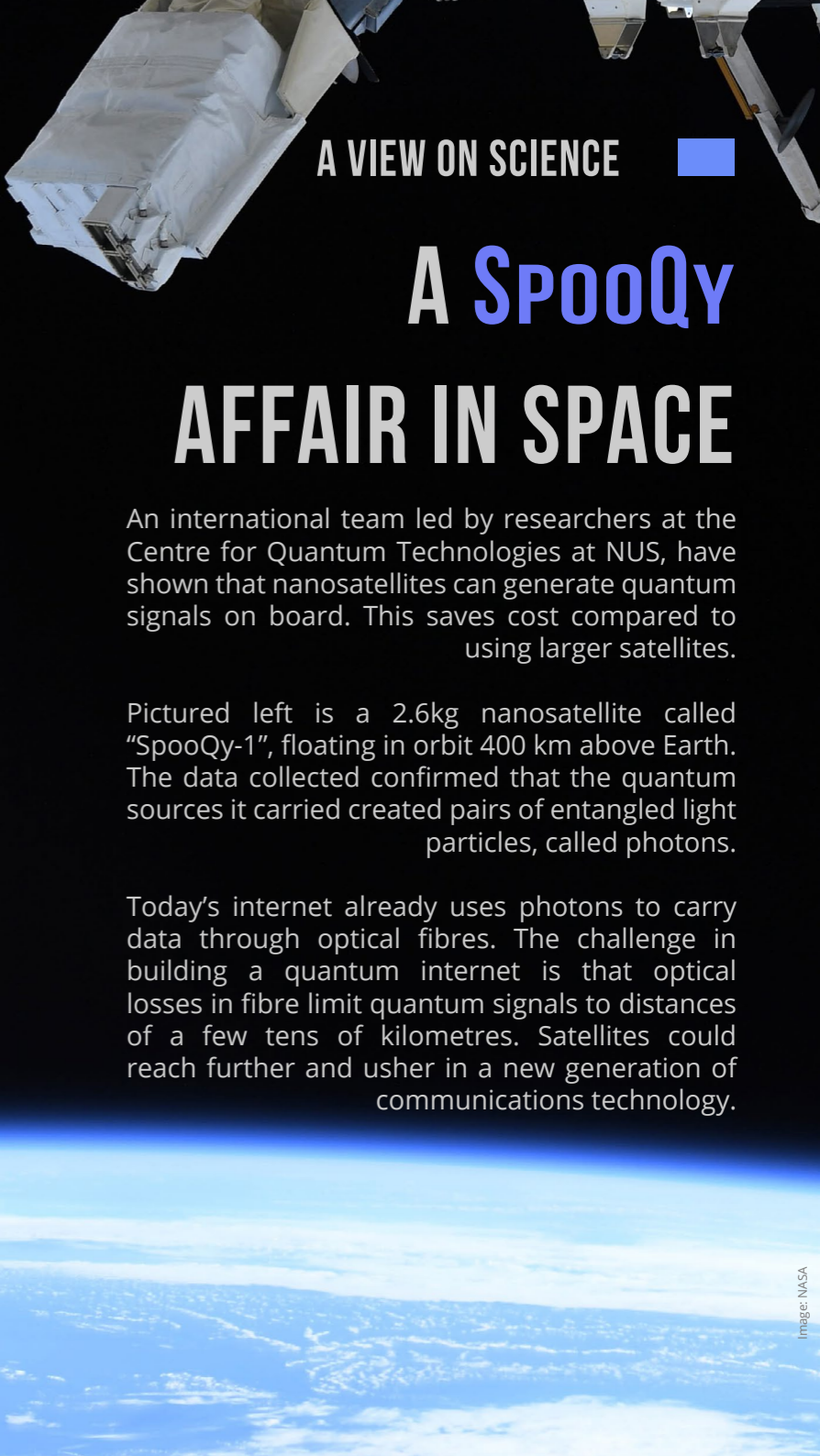
"Singapore already has an early start in the quantum arena as CQT has been nurturing researchers in this emerging field for a long time. Building up the local expertise in this field and continuing to attract top talents should be a priority to remain competitive in the global commercial landscape."

He shared that it is also essential that like-minded players in the industry come together and find synergies to develop different innovations, which advances the quantum technologies industry.

Mr Lum also added that SpeQtral had partnered with Japan-headquartered Toshiba Digital Solutions Corporation, which would promote reliable and ultra-secure quantum cryptography solutions to government agencies and companies in Southeast Asia."

"We are firm believers in collaboration. While SpeQtral already has a few ongoing initiatives, we are always open to further collaboration opportunities. This spirit of innovation is what drives SpeQtral. It is a vital ingredient for Singapore to position itself in the global market," said Mr Lum.

"Our vision is that satellite-based QKD would serve as the backbone of the global quantum-secure communication infrastructure. This bridges intercontinental distances and connects local fibre-based QKD networks in various metropolitan areas."



A VIEW ON SCIENCE

A SpooQy

**AFFAIR IN SPACE**

An international team led by researchers at the Centre for Quantum Technologies at NUS, have shown that nanosatellites can generate quantum signals on board. This saves cost compared to using larger satellites.

Pictured left is a 2.6kg nanosatellite called "SpooQy-1", floating in orbit 400 km above Earth. The data collected confirmed that the quantum sources it carried created pairs of entangled light particles, called photons.

Today's internet already uses photons to carry data through optical fibres. The challenge in building a quantum internet is that optical losses in fibre limit quantum signals to distances of a few tens of kilometres. Satellites could reach further and usher in a new generation of communications technology.

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